

CLAIMS

What is claimed is:

1. A medical prediction system configured to predict premature births, the system comprising:
 - an image storage configured to store ultrasound images, the ultrasound images including a fetus;
 - image analysis logic configured to provide a quantitative prediction that the fetus will be born prematurely based on the ultrasound images;
 - a user interface configured to provide at least the prediction that the fetus will be born prematurely to a user; and
 - a microprocessor configured to execute at least a part of the image analysis logic.
2. The system of claim 1, further comprising an image generator configured to generate the ultrasound images.
3. The system of claim 1 or 2, further comprising a data input configured to receive clinical data regarding the fetus or a mother of the fetus, wherein an estimated time until birth of the fetus is based on the clinical data.
4. The system of claim 1-2 or 3, further comprising feedback logic configured to guide acquisition of the ultrasound images based on a quality of the prediction that fetus will be born prematurely or classification of the images acquired into subject matter classes.
5. The system of claim 1-3 or 4, further comprising training logic configured to train the logic configured to estimate a time until birth of the fetus.
6. The system of claim 1-4 or 5, further comprising image acquisition logic configured to acquire medical data from social media sources, the medical data including training images and birth information, the training images being generated using ultrasound.
7. The system of claim 1-5 or 6 or method of claims 31-53, wherein the ultrasound images including the fetus are generated over a period of time including at least one, two or three months.
8. The system of claim 1-6 or 7 or method of claims 31-53, wherein the ultrasound images include doppler information, or fluid, bone or tissue density information.
9. The system of claim 1-7 or 8 or method of claims 31-53, wherein the image analysis logic comprises:

first logic configured to estimate a gestational age of the fetus based on the ultrasound images, the gestational age being at a time the ultrasound images were generated,
second logic configured to estimate a time until birth of the fetus based on the ultrasound images, and
logic configured to calculate an estimated gestational age of the fetus at birth of the fetus.

10. The system of claim 1-8 or 9, wherein the image analysis logic is configured to use a regression algorithm to provide an estimate that fetus a will be born prematurely within two or more time ranges, and optionally to estimate the time until birth, the regression algorithm optionally being a quantile regression algorithm.
11. The system of claim 1-9 or 10, wherein the image analysis logic is configured to use a regression algorithm that outputs a range prediction to provide an estimate that fetus a will be born prematurely, and optionally to estimate the time until birth.
12. The system of claim 1-10 or 11, wherein the image analysis logic is configured to provide an estimate that fetus a will be born prematurely using a classification algorithm, the classification algorithm including at least two or three classifications of birth timing.
13. The system of claim 1-11 or 12, wherein the image analysis logic includes a neural network configured to receive ultrasound images and to generate an output representative of the prediction that fetus a will be born prematurely.
14. The system of claim 1-12 or 13, wherein the image analysis logic includes a neural network configured to receive ultrasound images and to generate an output indicative of a time until birth of the fetus.
15. The system of claim 1-13 or 14, wherein the quantitative prediction that the fetus will be born prematurely includes an estimate of a probability that the fetus will be born prematurely, the estimate optionally being based on an image of a cervix and/or amniotic fluid index.
16. The system of claim 1-14 or 15, wherein the quantitative prediction is based on an ultrasound image including an endometrium and/or a uterine wall.
17. The system of claim 1-15 or 16, wherein the user interface is configured to provide at least two of: the gestational age, the estimated time until birth and the gestational age of the fetus at birth to a user.

18. The system of claim 2-16 or 17, wherein the image generator comprises a sound source, a sound detector and logic configured to generate the ultrasound images based on sound detected by the sound detector.
19. The system of claim 2-17 or 18, wherein the image generator is configured to adapt the generation of the ultrasound images based on an output of the image analysis logic.
20. The system of claim 2-18 or 19, wherein the image generator is configured to generate a sequence of images representative of motion of a fetus, the image sequence optionally including fetal blood flow, capillary perfusion, and/or heart movement.
21. The system of claim 2-19 or 20, wherein the image generator is configured to direct a user to modify a position of a sound source configured to generate the ultrasound images.
22. The system of claim 1-20 or 21, wherein the image analysis logic is further configured to predict that fetus a will be born prematurely based on the clinical data received via the data input.
23. The system of claim 22 or the method of claim 41, wherein the clinical data includes at least one of: mother genetics, mother weight, mother pregnancy history, mother blood glucose, mother heart function, mother kidney function, mother blood pressure, placenta condition, mother infections, mother nutrition, mother drug use (smoking & alcohol consumption), mother age, and/or mother cervix or uterus characteristics.
24. The system of claim 4-22 or 23, wherein the feedback logic is configured to guide a positioning of the image generator so as to generate images more useful in the prediction that the fetus will be born prematurely.
25. The system of claim 4-23 or 24, wherein the feedback logic is configured to indicate a need to acquire additional ultrasound images useful in the prediction that the fetus will be born prematurely.
26. The system of claim 1-24 or 25, wherein the image analysis logic includes a machine learning system and the training logic is configured to pretrain the machine learning logic to recognize features in the ultrasound images.
27. The system of claim 1-25 or 26, wherein the image analysis logic includes a machine learning system and the training logic is configured to train the machine learning system to make the quantitative prediction that the fetus a will be born prematurely.
28. The system of claim 1-26 or 27, wherein the image analysis logic includes a machine learning system and the training logic is configured to train the machine learning

system to use both a regression algorithm and a classification algorithm to make the prediction that the fetus will be born prematurely.

29. The system of claim 6-27 or 28, wherein the image acquisition logic is configured to acquire the training images from social media accounts, to acquire birth information including a birthdate from the same respective social media accounts, and to determine times between the generation of the training images and the respective birthdates.

30. The system of claim 6-28 or 29, wherein the image acquisition logic is configured to detect ultrasound images within social media accounts and is configured to detect associated birth announcements in social media accounts.

31. A method of generating a quantitative prediction of premature birth, the method comprising:

- obtaining a set of medical images including a fetus;
- analyzing the medical images using a machine learning system to produce the quantitative prediction, the quantitative prediction including an estimate of time until birth of the fetus or an estimate of a gestational age of the fetus at birth; and
- providing the quantitative prediction to a user.

32. A method of training a medical prediction system, the method comprising:

- receiving a plurality of medical images, the medical images optionally including ultrasound images of a fetus during pregnancy;
- optionally filtering the images to remove, from the plurality of medical images, images having poor predictive value;
- optionally classifying the images according to the views or features included within the images;
- optionally pretraining a neural network to recognize features within the images or types of images;
- training the neural network to provide a quantitative prediction regarding birth of the fetus, the quantitative prediction including an estimate of a gestational age of the fetus at birth, or including an estimate of a current gestational age of the fetus and an estimate of remaining time until birth of the fetus; and
- optionally testing the trained neural network, to determine accuracy of the quantitative predictions.

33. A method of acquiring ultrasound images for training a neural network, the method comprising:

- scraping a social media account;
- identifying a fetal ultrasound image in the social media account;
- identifying a birth announcement within the social media account;
- calculating a time between posting of the ultrasound image on the social media account and posting of the birth announcement on the social media account; and
- using the ultrasound image and calculated time to train a neural network to generate a prediction that an ultrasound image is indicative of a premature birth, the prediction optionally being a quantitative prediction.

34. A method of identifying a beneficial therapy based on medical predictions, the method comprising:

- determining a quantitative prediction of a future medical condition, the quantitative prediction including a probability that the medical condition will occur within a future time range and being based on analysis of medical images of a patient;
- providing a candidate therapy for the medical condition to the patient;
- repeating the steps of determining a quantitative prediction of a future medical condition and providing a candidate therapy for plurality of patients;
- determining if the candidate therapy resulted in a statistically relevant benefit to the plurality of patients at their respective time ranges; and
- identifying the candidate therapy as the beneficial therapy based on the statistically relevant benefit.

35. The method of claim 31-33 or 34, wherein the medical images include ultrasound images of the fetus or a mother of the fetus.

36. The method of claim 31-34 or 35, wherein the medical images include any of the image types or features discussed herein, and are optionally classified as such.

37. The method of claim 31-35 or 36, further comprising receiving clinical data regarding the fetus or a mother of the fetus, wherein an estimated time until birth of the fetus is based on the clinical data.

38. The method of claim 31-36 or 37, further comprising providing the user with feedback regarding acquisition of the ultrasound images based on a quality of the prediction or a subject classification of images already acquired.
39. The method of claim 31-37 or 38, further comprising training the machine learning system to estimate a time until birth of the fetus, a gestational age of the fetus at birth, and/or a current gestational age of the fetus.
40. The method of claim 31-38 or 39, wherein analyzing the medical images includes using a quantile regression algorithm to provide an estimate that fetus a will be born prematurely, and optionally to estimate the time until birth, the quantile regression algorithm being configured to classify an estimated gestational age of the fetus at birth into one of at least two or three time ranges.
41. The method of claim 31-39 or 40, wherein the quantitative prediction is further based on the clinical data regarding a mother of the fetus received via a data input.
42. The method of claim 31-40 or 41, wherein analyzing the medical images includes to using a quantile regression algorithm and/or a classification algorithm to make the prediction that the fetus a will be born prematurely.
43. The method of 31-41 or 42, further comprising balancing the images based on a subject matter classification of views or features.
44. The method of 31-42 or 43, further comprising balancing quantities of the images based on gestational age at birth.
45. The method of claim 31-43 or 44, wherein the quantitative prediction is made using one of the systems or methods claimed herein.
46. The method of claim 31-44 or 45, wherein the candidate therapy is only provided to patents having a quantitative prediction of the medical condition occurring within the time range of greater than 50%, 66% or 75%.
47. The method of claim 31-45 or 46, wherein the medical condition is the premature birth of a fetus.
48. The method of claim 31-46 or 47, wherein the medical condition is not present or apparent in the medical images at a time the quantitative prediction is determined.
49. The method of claim 31-47 or 48, wherein the candidate therapy includes a pharmaceutical or physical treatment.

50. The method of claim 31-48 or 49, wherein the candidate therapy is provided to the plurality of patients prior to the patients exhibiting any symptoms of the medical condition.
51. The method of claim 31-49 or 50, wherein determining if the candidate therapy resulted in a statistically relevant benefit includes providing some patients placebos.
52. The method of claim 31-50 or 51, wherein a time between determining the quantitative prediction and the time range is at least 1, 2 or 3 months.
53. The method of claim 31-51 or 52, wherein the medical condition is any of the medical conditions discussed herein.
54. The system of claim 1-30 or the method of claim 31-53, wherein the image source includes an ultrasound machine.